Deep Wells - Some Environmental Implications

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Abstract

90% of Sri Lanka consists of crystalline rocks. The scarcity of surface water resources, particularly in the Dry Zone, makes groundwater investigations in the crystalline rocks a most timely venture. Nearly 15000 tube wells have been drilled and planners and hydrogeologists should now evaluate the success and the problems of the scheme. While there are obvious advantages in the installation of tube wells in areas where surface water is scarce, the disadvantages should be scientifically studied and remedial measures taken. Many of the problems arise from the chemistry of the water. Apart from the determination of the water quality due to the corrosion of the mechanical installations such as GI pipes and pumps, there are natural factors that cause problems of water quality. The hydrogeochemists in particular should take a closer look at the excesses of certain chemical elements and species that are found in many deep wells. Excess quanitities of fluoride, manganese, iron, nitrates etc. have been observed and their implications on community health may well turn out to be a major problem. The development of low cost, effective refining techniques using local raw material must necessarily take priority. The successful implementation of a deep well water supply scheme demands active and effective community participation. A rural development scheme of this nature therefore requires the dissemination of basic information at the grass root level and the geoscientists have to play a major role and fulfil their obligations to the public at large.

Introduction

Water is perhaps the most basic resource. Yet, in many parts of the world, it is an extremely scarce and hence a most valuable resource. As reported in Economic Review (People's Bank Publication) (1984), in 1975, an estimated 78% of rural populations from 75 developing countries (excluding China) did not have reasonable access to safe drinking water. In absolute figures, this corresponded to 1106 out of 1419 million rural people without safe water. For sanitation the situation was still worse, with 85% of the rual population without adequate facilities.

As 1990, the year in which all people are to be provided with good quality water approaches, many problems still remain and vast populations still do not get sufficient safe water. In Sri Lanka, while concerted efforts are being made to provide safe water for all, many areas, particularly in the Dry Zone, do not have adequate, easily accessible water resources. With approximately 75% of the population living in a rural environment, adequate water supplies and proper sanitation have become a major concern of the authorities. The difficulty of providing an uninterrupted water supply to the Dry Zone population is enhanced by the fact that geologically much of the terrains comprise of hard crystalline rocks and that surface water resources are inadequate. The need for tapping groundwater resources in crystalline rock terrains has therefore become an obvious area of research and geoscientists have a major contribution to make in implementation of rural water supply schemes.

Groundwater in Crystalline Rocks

One of the ways to tap the deep groundwater resources in the crystalline rocks is to drill deep holes, often reaching 70-100 metres and pump out the water collected through fractures and other secondary porosities. The tube well concept which was first introduced to Sri Lanka around 1979 has now become a very popular means of supplying water to those regions in which surface water is scarce. At present, nearly 15000 deep wells have been drilled with many foreign organizations including DANIDA, FINNIDA, UNICEF, GTZ among others implementing large-scale water supply schems. The advantages and disadvantages of deep wells have often been the subject of much controversy and time is now opportune for hydrogeologists and hydrogeochemists to make a scientific assessment of the pros and cons.

Since 90% of Sri Lanka comprises of the crystalline or hardrock terrains, a proper evaluation of the groundwater potential of the hard rock areas is absolutely essential. Studies on rainfall, evaporation, seepage and re-charge rates, surface run-off, etc. all need to be considered in a study aimed at evaluating the groundwater potential in hard rock terrains. Further, the geologist is required to study in detail the lineament and fracture systems that eventually create the secondary porosity, the water-bearing capacities of the different rock types, and re-charge rates. A concerted effort by the climatologists, geographers and hydrogeologists is therefore needed to make a true assessment of the hardrock groundwater potential.

Deep Wells and Shallow Open Dug Wells

The advantages and disadvantages associated with deep wells is best studied with respect to the shallow dug wells that form the main water supply to a vast number of people in Sri Lanka. This comparison is illustrated in figure 1. The most striking difference between the shallow dug well and deep well lies in their different physical and geochemical environments. As shown in fig. 1, the shallow dug well is located mostly in the unconsolidated overburden and the water table fluctuates seasonally within this region. The deep well on the other hand lies in the perennial water zone and receives its water only through the cracks and fissures in the hardrock as against the passage of water through the loose sand and soil particles in the case of the shallow wells. The closeness of the shallow well water with the surface exposes the water to dangers of contamination. The close proximity of many shallow wells to soakage pits and pit latrines has resulted in high nitrate levels being found in many shallow wells with the distinct possibility of bowel diseases and other gastric disorders among the consumers. As pointed out by many scientists, attention is sharply focussed on the problem of the intake of excessive nitrates, as these compounds on reduction yield nitrite and secondary amines known to be carcinogenic. The work of Dissanayake and Weerasooriya in the compilation of the Hydrogeochemical Atlas of Sri Lanka has shown that shallow wells dug in the more porous rock materials such as sedimentary limestone, as found in the Jaffna peninsula, receive a much higher content of nitrates mostly from pit latrines and fertilizer applications.

The deep well on the other hand show a much lower nitrate content, as observed from the analyses of a large number of deep wells. However, if the deep well passes through a highly contaminated surficial overburden, the contaminated-aterial could easily reach the deep well water through the fractures in the hardrocks, aided by the lack of a natural filtering mechanism. Such a case from Sri Lanka was reported by Lawrence (1986), where a tracer experiment in a fractured basement aquifer demonstrated the time for water to travel from the pit latrine soakaway to a water-supply tube well some 20–25 m away to be only 2–3 days. This result was clearly disturbing as it indicated that the tube well is likely to be heavily polluted by pathogens originating from the pit latrine. It is therefore very necessary to (a) assess how typical this result is and (b) to understand the transport mechanism of micro-organisms in weathered and fractured aquifers. Even though shallow dug wells are much more prone to contamination via surface phenomina, the deep well water should also be continuously monitored for pathogens.

A closer scrutiny of figure 1 shows that it is the immediate geochemical environments of the shallow wells and the deep wells that need careful investigation. The quality of the water is a direct result of these geochemical environments. While the shallow wells have an often organic-rich and loosely packed soil environment, the deep wells, particularly in the unlined regions have a geochemical environment dominated by unweathered rocks. The amount of dissolved matter depends on this geochemistry and it would be extremely informative to carry out a statistical comparison of the chemical quality of the shallow well and deep well water.

Chemical Quality

In a recent study on the behaviour of some chemical parameters in tube well water in Matale and Polonnaruwa Districts. Christensen and Dharmagunawardhane (1987) have shown that although the quality of tube well water is in many respects much superior to that of the traditional sources in the villages (open dug wells, pits, streams, irrigation canals, reservoirs, etc.), villagers seem to pay more attention to the taste of tube well water which result from the solution of mineral matter. Rusty taste due to the presence of iron, hardness due to calcium and magnesium compounds, and occasionally salty taste due to chloride are the most common reasons for complaints.

An introduced problem generally present in tube wells is the "iron problem" caused by the corrosion of pumps, and galvanized iron pipes. In a number of cases, within 1 year of installation, tube well water showed excessive iron concentrations due to dissolution of iron from G.I. pipes aided by a low pH in the groundwater. More recently, high density polyethylene pipes have been used instead of GI pipes and the "iron problem" can be alleviated.

However excessive concentrations of iron, calcium and magnesium in tube well water due to natural geological factors, still remain a problem in many parts of Sri Lanka (Fig. 2). Recent work carried out by researchers of the Finnida, Kandy Water Supply Project (J. P. Padmasiri – Person. Comm.) has shown that in certain parts (eg. Udunuwara and Mahiyangane) the tube wells contain excessive manganese concentrations. It could also well be that there are other metals that may be found in undesirable quantities in the tube well water. This is not surprising in view of the fact that the crystalline rocks through which the wells are drilled very often contain higher concentrations of metals. This is particularly seen in mineralized zones such as the Highland – East Vijayan boundary.

The Fluoride Problem

A problem of growing concern is the excessive concetration of fluorides found in many deep wells in the Dry Zone notably in the Anuradhapura and Polonnaruwa Districts. In many of these deep wells the fluoride concentrations exceed 1.5 Mg/ l and pose a health hazard to the consumers. Indeed, there is wide prevalence of dental fluorosis with a few isolated cases of skeletal fluorosis. What is of great importance is that, in general, the deep wells appear to contain more fluorides than the open shallow dug wells. Fluorides tend to be found in abundance in granitic terrains and in those areas with rocks containing mica, hornblende, apatite, etc. Deep seated fractures also act as conduits in the transport of fluoride-rich fluids. With thousands of tube wells planned for the next decade, hydrochemists must find appropriate effective and cheaper ways of removing the excessive harmful fluoride concentrations from the tube well water.

Obtaining Best Quality Deep Well Water

Since the deep well tap water from a geochemical environment that is very different from that of the shallow open dug wells, it is obvious that the consumers are now exposed to totally new elemental concentrations. While some chemical elements and species are highly beneficial to health, other found in excessive concentrations, such as fluorides, nitrates, manganese and iron may prove to be detrimental to health. It is imperative therefore that the water be refined to optimum levels so as to be beneficial to health. The problems of bringing the water quality to the optimum levels are magnified due to the fact that these deep wells are located in rural areas and expensive and sophisticated refining techniques are not cost effective. What is required therefore are appropriate chemical refinements involving easily available local raw materials and which are acceptable to the rural folk — the ultimate consumer. The problem of excess fluorides in the deep wells of the Dry Zone has been clearly identified and experiments are now being carried out with the final objective of developing an effective defluoridation technique at the village level using local raw materials. Clay, charcoal, serpentine and dolomite are some of the raw materials that are being used in the experiments. All hydrochemists working on the development of water refining techniques, must remember that the rural folk have their own concepts of what good and acceptable water quality should be and whatever the technique is, the villager must eventually accept it. There are many deep wells that have had to be abandoned in view of the fact that the taste of the water was not acceptable to the village consumer. In view of the wide usage of agrochemicals, the amount of agro-chemicals that are found in tube wells is another aspect that needs careful consideration, in the future.

Maintenance, Management and Education

When tackling problems of community water supplies, a major role must necessarily be played by the community, for whom the water supply is implemented. The community is expected to play this vital role in all stages of a water supply namely:

(a) Preliminary investigation, feasibility and planning
(b) Preparation of the most feasible proposal
(c) Design stage
(d) Implementation stage
(e) Operation and maintenace stage.

The obvious question that arises is, to what extent can be community contribute to this development effort? How knowledgeable are they on problems of public water supply? In order to get the maximum benefit out of these water supply schemes, it seems very necessary for our consumers to be educated in practically all aspects of planning, implementation and maintenance. The latter in particular is vital for the rural sector since much of the maintenance and repair costs could be minimised by the proper utilisation of the facilities provided. It is my view that the geoscientists have a major role to play in bridging the knowledge gap between the consumer and the planner. Rural education through whatever media will eventually bring the desired results. Educating the rural consumer on the hydrological cycle, principles of conservation, basic water management, sanitation, maintenance of appliances such as pumps, pipss, refining apparatus, etc. can quite easily be carried out with the help of field officers. The experience of the rural consumer will also be invaluable to the planners and they too can educate themselves on the realities and problems of rural water supply.

FIGURE CAPTIONS

Figure 1: A schematic representation of the geochemical environments of dug wells and the deep wells.